SMART
Singapore-MIT Alliance for Research and Technology

Professor Nam-Trung Nguyen Explains the Big Deal behind Nanofluidics

Dr Nam-Trung Nguyen first came to Singapore as a Research Fellow at NTU in 1999, but the Vietnamese-born professor had spent considerable time in Europe as well as North America prior to that. Not surprisingly, he's a multilinguist fluent in not only Vietnamese and English, but also Mandarin, German, and, he says, "a bit" of Russian.

His collaboration with SMART began with SMAII. "I visited MIT in 2006, and Roger Kamm (PI at BioSyM) asked if I would like to be a collaborator in the SMART program as a continuation of the work I'd begun under SMAII. Given the success of my previous collaboration, and the excitement of having a program like SMART in Singapore, I couldn't say no!" Prof Nguyen enthusiastically says.

The research that Prof Nguyen pursued under SMAII involved machining polymeric devices for microfluidic and nanofluidic functions. In other words, Prof Nguyen creates micro- and nanochannels on polymeric materials that can be used to perform specific tasks.

How small is micro? Prof Nguyen explains, "A microchannel can be as big as a human hair, about 100 micrometers. But we wanted to make smaller channels, at the nano level. These channels are on the order of 100 nanometers, or about 1,000 times smaller than the diameter of a human hair." In other words, you'd have to bundle one million of these channels together to equal the size of a single human hair.

Working at such a tiny scale presents problems not only with the fabrication of the devices, but also with fundamental physical properties of fluid flow. "The physics are new because previously people could not observe phenomenon at this scale. But now we can make channels at the nano scale relatively inexpensively, so we can investigate all the phenomena which happen in the channels, especially involving fluids." Prof Nguyen notes that "this is leading to all sorts of new tasks for the micro and nano devices that we did not previously envision."

Finding Malaria

Prof Nguyen's collaboration with BioSyM uses microcoils and nuclear magnetic resonance (NMR) measurements to detect malaria parasites in human blood. To do this, his team excites atoms in the blood with an electromagnetic field, and then suddenly stops the field and lets the atoms oscillate at their own resonance frequency. They can then analyse the signal to detect anomalies such as parasites.

But performing such a test is no easy matter, especially with conventional materials. "To have an electromagnetic field, you need microcoils in the device. Previously microcoils were made from metal wire." Prof Nguyen elaborates on the dilemma, "This creates problems with heat dissipation because the wire layers are thin and the coil takes a large amount of current."

For the microcoil, his team pioneered a breakthrough approach by making the coils out of moulded polymer microchannels. “Into these channels we put liquid metals that have very low melting temperatures. They are better suited to this experiment than conventional metals. The coils both excite and pick up the resonance of the atoms.” Incredibly, the entire microfluidic device is about the size of a human fingernail.

Eventually Dr Nguyen and his team would like this technology to become inexpensive enough to equip field hospitals or medical stations in places that don’t have access to lots of laboratory equipment with a low cost, simple to use, small device to detect malaria infections.

Making potable water

The base technology developed by Prof Nguyen’s team can be used in a variety of applications. In addition to this project with Prof Han at BioSyM, he has another project supported by the SMART Innovation Center. “We received a grant working on water desalination using similar technology, which means based on nanofluidic polymer technology.” Prof Nguyen explains, “In the nanochannels of the devices we create, a liquid flow behaves differently than at what we think of as ‘normal’ scale. We can make nanochannels that are so small that they can repulse the salt ions and only let water flow through. So you put in salt water and out comes potable water from one pipe and the excess salt out another!”

This concept of “ion polarization” was first published by Prof Han’s group at MIT, though the SMART Innovation Centre grant will help to push this technology closer to commercial application. By having micromachining facilities available at NTU, the team can fabricate these devices in Singapore. Hopefully they will soon be available for public use.

“Because we’re dealing with the microscale,” Prof Nguyen says, “this technology won’t be available at the city-scale, but more like for small communities, perhaps even at the scale of individual homes.”

Within easy reach

As someone who has lived, studied, and worked on three continents, Dr Nguyen brings a unique perspective to the value of SMART for a country like Singapore. “We can always collaborate with faculty overseas, but face-to-face discussions are always more fruitful. Sometimes good ideas come up during brainstorming exercises or during lunch. For local researchers, this is a chance to have a collaboration in which we don’t necessarily have to travel to MIT. From NTU to the NUS campus and the SMART facility is only about a 30 minute drive, not a 30 hour flight!”

It’s also a great opportunity for Prof Nguyen’s students. “Collaborators co-supervise the researchers in SMART, and I have one PhD student funded by a SMART scholarship. So this student works for SMART but is officially attached to me at NTU. Through such a system we can broaden our students’ access as well.”

As a Southeast Asian, the weather and the culture of Singapore are familiar to Prof Nguyen, who has lived for the past 13 years on the NTU campus with his wife and three children. Two of his children attend schools in Singapore. “Singapore has a wide spectrum of schooling opportunities. Kids can go to local schools that have a very high standard, or there is also a good range of international schools,” Prof Nguyen says. In fact, one of his children goes to local school, while the other attends an international school.

And what about differences in culture between Orient and Occident? “Sometimes the culture can be difficult for Western people. Singapore may look very Western on the outside, but the people are still Asian and they have different ways to express themselves,” Prof Nguyen muses. “Often Asians are not very direct in their expression, because they perceive directness to be aggressive. Americans, especially, are usually more direct and say straightaway what they want. Sometimes this can lead to conflict. You need to have patience in Asia, especially to figure out what the Asian counterpart wants.”

But with that caveat I mind, Prof Nguyen is enthusiastic about having more MIT professors participate in the SMART program and collaborate with local faculty. “I hope to see more faculty from MIT from different departments and fields, so we can have a wider range of disciplines to work with here in Singapore.”

Expanding the SMART program is one way that extraordinarily talented faculty like Prof Nguyen can engage with international peers to develop technology that will make the world a better place without ever having to leave Singapore.

Dr Nam-Trung Nguyen is an Associate Professor at the School of Mechanical and Aerospace Engineering at Nanyang Technological University. In addition, he is also Professor in Charge of Micromachine Labs 1 and 2 and Director of NTU’s Part-Time BEng Programme. Author of over nine books and several hundred journal and conference articles, Prof Nguyen earned his PhD, summa cum laude*, in 1997 from Chemnitz University of Technology (Germany), and was a Post-Doctoral Research Engineer at University of California Berkeley. He had been granted three patents in the United States, and in 2011 was Elected Fellow of American Society of Mechanical Engineers. Recently he was named a “SMART Fellow” in recognition of his contribution to the BioSyM research group, with which he collaborates with Han Joonyong.*

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